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Remaining Issues over Hazardous Waste Thermal Destruction

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16. ABSTRACT

Since 1980, the U.S. Environmental Protection Agency (EPA) has conducted extensive research to assess the performance of hazardous waste thermal destruction processes. This research has been designed to support the development and implementation of regulations and standards for controlling the safe operation of thermal destruction facilities in the United States. While these studies have largely shown thermal destruction to be the most practical and effective technology available for ultimate control of organic hazardous waste materials, some members of the scientific and the environmental action community remain concerned about the long-term safety of the technology. The issues most frequently raised pertain to the possibility that harmful levels of heavy metals and incomplete combustion by-products may still be emitted from thermal destruction facilities that are otherwise meeting the current RCRA standards. The lack of available real-time monitoring techniques for tracking thermal destruction efficiency and detecting possible process upsets adds to the uncertainty and perceived risks associated with facility operation.

This paper will summarize the most recent data on thermal destruction facility performance with particular attention to metal and organic by-product emissions. Ongoing EPA research in this area and in real-time monitoring will be discussed. Real versus perceived concerns over thermal destruction will be put in perspective.

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REMAINING ISSUES OVER HAZARDOUS WASTE THERMAL DESTRUCTION

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ABSTRACT

Since 1980, the U.S. Environmental Protection Agency (EPA) has conducted extensive research to assess the performance of hazardous waste thermal destruction processes. This research has been designed to support the development and implementation of regulations and standards for controlling the safe operation of thermal destruction facilities in the United States. While these studies have largely shown thermal destruction to be the most practical and effective technology available for ultimate control of organic hazardous waste materials, some members of the scientific and the environmental action community remain concerned about the long-term safety of the technology. The issues most frequently raised pertain to the possibility that harmful levels of heavy metals and incomplete combustion by-products may still be emitted from thermal destruction facilities that are otherwise meeting the current RCRA standards. The lack of available real-time monitoring techniques for tracking thermal destruction efficiency and detecting possible process upsets adds to the uncertainty and perceived risks associated with facility operation.

This paper will summarize the most recent data on thermal destruction facility performance with particular attention to metal and organic by-product emissions. Ongoing EPA research in this area and in real-time monitoring will be discussed. Real versus perceived concerns over thermal destruction will be put in perspective.

Introduction

Since 1980, the U. S. Environmental Protection Agency (EPA) has conducted waste destruction performance tests at nearly 50 full-scale hazardous waste thermal destruction facilities in the United States. The facilities tested have included:

- commercial and on-site incinerators
- incineration ships
- cement kilns
- industrial boilers
- commercial boilers
- light weight aggregate kilns
- steel blast furnace
- batch asphalt plants

The principal objective of these tests has been to characterize stack emissions and residues to determine if these facilities are capable of meeting the waste destruction and control requirements of current EPA regulations and standards. In the case of hazardous waste destruction, the incineration standards promulgated under the Resource Conservation and Recovery Act of 1976 (RCRA) are the required (for incinerators) or chosen (other thermal destruction processes) performance benchmark. These standards require that facilities must demonstrate that they can attain:

(1) 99.99 percent destruction and removal efficiency (DRE) for each principal organic hazardous constituent (POHC) in the waste feed where:

$$DRE = (W_{in} - W_{out})/W_{in}) \times 100$$

Where: W_{in} = Mass feed rate of the principal organic hazardous constitutent (POHC) in the waste stream fed to the incinerator.

W_{out} = Mass emission rate of the POHC in the stack prior to release to the atmosphere.

(2) At least 99 percent removal of hydrogen chloride from the exhaust gas if hydrogen chloride stack emissions are greater than 1.8 kg/hr.

(3) Particulate matter emissions no greater than 180 mg/standard m^3 corrected to 7 percent oxygen in the stack gas. The measured particulate matter concentration is multipled by the following correction factor to obtain the corrected particulate matter emissions:

$$\text{Correction Factor} = 14/(21-Y)$$

Where: Y = measured oxygen concentration in the stack gas on a dry basis (expressed as a percentage).

The results of most of these performance tests have been compiled in published EPA reports and summarized in published papers.[1-7] The data have shown that properly designed and operated incinerators, industrial boilers, cement kilns, and certain other industrial furnaces are capable of achieving or exceeding the RCRA DRE and hydrochloric acid gas requirements. The EPA also has conducted risk assessments using the emissions from the incinerators, boilers, and cement kilns tested. These assessments concluded that residual organic compounds in stack emissions posed no significant health risk.[8-10]

Remaining Issues

While thermal destruction represents the most effective and widely applicable control technology available today for organic hazardous waste, a number of issues remain concerning its use in the long term. These include:

- Destruction effectiveness on untested/unique wastes
- Detection of process failure
- Control of heavy metal emissions
- Emissions of combustion by-products
- Available thermal destruction capacity
- Permits and public acceptance

This paper will attempt to define each of these issues more fully, present applicable data and other information to put these concerns into some perspective, and summarize ongoing EPA research designed to improve our understanding in these areas.

Untested Wastes

All of the performance data which have been used in the development and assessment of thermal destruction regulations and standards have obviously been collected for waste/thermal-technology combinations typical of current practice. Industrial boilers and cement kilns, for instance, typically fire only liquid wastes which are moderate-to-high in heat content (8,000 to 18,000 Btu/lb) and relatively low in chlorine (3 to 10 percent by weight in the wastes) and metals.[9-10]

For incinerators, the greatest amount of waste handled is corrosive waste identified by EPA waste code D002, accounting for 29 percent of the weight of wastes incinerated under the RCRA program.[11] Approximately 8 percent of the wastes are ignitable (D001), 8 percent are reactive (D003), 5 percent are spent halogenated solvents (F001). The average heating value of all reported wastes is 8,500 Btu/lb. Forty-six percent by weight of the wastes are halogenated with an average halogen content of 33.2 percent. The average solids content of the reported wastes is 7.9 percent and the average water content is 50.5 percent.

However, the character of wastes which may be subjected to incineration in the near future will begin to change, perhaps dramatically. These changes

will be influenced by EPA action to restrict many wastes from land disposal under the Hazardous and Solid Waste Act Amendments of 1984 (HSWA) and by increased emphasis upon remedial action at "Superfund" sites. Incineration will emerge as a feasible technological alternative for destruction of many of these wastes and site clean-up residues. However, EPA and industry will have considerably less experience in handling these wastes. They will tend to have higher solids and water content, be more complex in their physical and chemical composition, have lower heat content, and potentially contain higher levels of hazardous metals and high hazard organics compared to wastes which are typically incinerated today.

Consequently, while incineration is capable of achieving high levels of destruction for today's wastes, future wastes may place new performance demands on current technology. For instance, 99.9999 percent DRE is now required for wastes bearing chlorinated dioxin and furan compounds. Many of these wastes appear at Superfund sites. EPA is also studying the need for heavy metals control regulations for incinerators. That effort may suggest the need for improved air pollution control systems or waste pretreatment. Thus, performance testing of incinerators and other thermal destruction devices must continue in order to assure destruction and removal effectiveness for these untested wastes, to assess process limitations and waste pretreatment requirements, determine the safety of process residues, and to improve our ability to predict performance on new waste materials.

Detection Of Process Failure

While well-operated thermal destruction facilities achieve high levels of organic hazardous material destruction, little is known about the impact of process upsets or failure modes upon emissions. This is often a concern of the public in hearings and permit actions.

While convincing trial burn performance data can be presented, uncertainty and distrust may exist regarding the reliability of thermal destruction systems in day-to-day operation after a permit is approved and when regulators are not present.

Currently, permit conditions are primarily based upon process operating conditions which are documented during the conduct of a successful trial burn; i.e., one which demonstrated that the facility achieved or exceeded the RCRA performance standards. Operating conditions (e.g., combustion temperature, O_2, and CO in stack emissions, etc.) must be used as surrogates for similar high performance after the fact since there is currently no real-time method to determine DRE for specific POHCs. DRE can only be determined with certainty via expensive, often multi-day testing procedures. Analysis results may take weeks or months to complete. While EPA believes this approach is reasonable and protective of public health and the environment, many argue that the availability of a real-time monitoring technique to detect process upsets and alert operators to automatically take corrective action would significantly increase public acceptance of thermal destruction technology.

EPA is currently conducting extensive research to assess the impact of the most likely process failure modes upon performance. The failure conditions being studied include: improper waste atomization; overfeeding or unstable feeding of waste; inadequate combustion temperature; post-combustion quenching of destruction reactions; inadequate combustion mixing; and a variety of other process-specific variables. This research is being conducted in laboratory- and pilot-scale incineration systems at EPA facilities in Cincinnati, Ohio, Research Triangle Park, North Carolina, and Jefferson, Arkansas. The experimentation is attempting to correlate process failure with a variety of potential performance indicators which can be inexpensively measured more or less instantaneously. The indicators currently being examined include: total unburned hydrocarbon emissions (TUHC); carbon monoxide emissions (CO); oxygen levels in stack emissions (O_2); and emissions of tracer compounds such as sulfur hexafluoride and various freons which could be added to a waste stream and be monitored as a potential surrogate for other organic compound destruction.

Results to date have not conclusively shown a universal correlation of any of the performance indicators with DRE. It appears that such correlations may be very waste and facility specific. TUHC and CO emissions appear to hold the most promise. As the research progresses, EPA hopes that statistical and engineering analysis will reveal a reliable approach which could be used during the trial burn to calibrate individual facilities for a DRE/surrogate relationship. The appropriate monitor could then be used for process control or compliance monitoring during normal operation.

Metal Emissions

Metals such as arsenic, barium, berylluim, chromium, lead, mercury, nickel, and zinc are of possible concern in waste incineration because of their presence in many hazardous wastes and because of possible adverse health effects from human exposure to emissions. Incineration will change the form but not the content of metal fractions in waste streams. As a result, metals are expected to emerge from the combustion zone essentially in the same total quantity as the input. The principal environmental control concern therefore centers around where and in what physical or chemical form the metals report in the combustion system, i.e., bottom ash, fly ash, in APCD residues, or stack emissions.

The primary controller for metals emissions from incineration is the RCRA particulate emission standard of 180 mg/dry standard cubic meter. Half of the incinerators evaluated in EPA's incinerator testing program (4 of 8) failed to meet this standard. Two of the facilities which failed did not have particulate pollution control systems. The other two units employed somewhat dated and poorly-maintained systems. Similar results are also being observed in trial burn data being submitted to EPA in permit applications.

Data were collected on actual metal emissions during the EPA incinerator testing program, as well as during certain of the other facility tests (cement kilns, waste oil combustion, boilers). As part of EPA's Regulatory Impact Assessment performed to examine the impact of the regulations on the regulated community

and to examine the health and environmental effects of the regulation, the risks due to emissions of principal organic hazardous constituents (POHCs), combustion by-products (PICs), and metals were developed and presented for incinerators.[8] The overall summary of results is presented in Table 1.

TABLE I. Total excess lifetime cancer risk to the maximum exposed individual for incinerator emissions

POHCs	10^{-7} to 10^{-10}
PICs	10^{-7} to 10^{-11}
Metals	10^{-8} to 10^{-5}
TOTAL	10^{-8} to 10^{-5}

The risks from metals emissions ranged from two to six orders of magnitude higher to one order of magnitude lower than from POHCs and PICs, and dominated the total risk values.

The risk estimates for metals were based on emission measurements from the stack sampling program conducted during the tests. The metals analyses were conducted on the particulates collected during stack sampling. The risk analysis for metals was conducted in two parts; for metals exhibiting carcinogenic properties, and for non-carcinogenic effects (threshold) for a range of metals.

While these results show that the health risks of most wastes in most incinerators are low, risks from metal emissions show the greatest potential for exceeding a 10^{-6} cancer risk. This is particularly true for facilities which may be operating at or near the RCRA particulate emission standard or those which may wish to incinerate waste higher in metal content in the future

EPA is considering various regulatory options for controlling metal emissions from hazardous waste thermal destruction facilities. To support the development of these potential regulations, research is underway to assess the character and fate of metals in incineration systems as a function of incinerator design and operation, waste characteristics and air pollution control system operation. Testing in pilot-scale incinerators will be conducted at EPA's Combustion Research Facility in Jefferson, Arkansas to develop metal partitioning models for conventional incineration system configurations. These models will be verified in field tests of commercial systems. The waste impact of pretreatment or improved air pollution control systems will be assessed in the research program.

Combustion By-Product Emissions

The current RCRA incineration standards regulate destruction and removal only for the major hazardous compounds in the waste. One of the concerns expressed by scientists and environmentalists regarding hazardous waste thermal destruction is the possible impact on human health and the environment of emissions of potentially hazardous products of incomplete combustion or PICs. This concern prevails in spite of the fact that EPA assessments have indicated that the risks from PIC emissions are low. In case of incinerators, Table I shows that the total excess lifetime cancer risk to the maximum exposed individual are essentially the same for PICs and POHCs, and both are less than 10^{-7}. Analysis of emissions data from tests of hazardous waste destruction in industrial boilers revealed that risks from PICs were consistently higher than POHC emission risks, but that again neither risk was ever greater than 10^{-6}.[10]

One basic issue which remains unresolved is the definition of a PIC. While a POHC is defined in the RCRA regulations, a PIC is not in a rigorous sense. Thus, there is often confusion even among scientists working in the area. Strictly speaking, PICs are organic compounds which are present in the emissions from the combustion process, which were not present or detectable in the fuel or air fed to the combustor. In EPA's test program, compounds were considered to be PICs if they were regulated organic compounds (i.e., listed in Appendix VIII of CFR 40 Part 261) which were detected in stack emissions, but not present in the waste feed at concentrations greater than 100 ppm.

Compounds in the emission stream which are identified as PICs can actually be any one of the following:

1. Compounds resulting from the incomplete burning of the principal organic hazardous constituents (POHCs), i.e., fragments of the original POHCs.

2. New compounds "created" in the combustion zone and downstream as the result of partial destruction followed by recombination with other compounds or fragments present.

3. A compound originally present in the feed stream before combustion but not specifically identified as a POHC.

EPA field studies of thermal destruction systems have identified 55 Appendix VIII compounds (28 volatile and 27 semi-volatile) in stack emissions.[1,2,5] These compounds were emitted at rates that span over five orders of magnitude, 0.09 to 13,000 nanograms of emissions per kilojoule of combustor heat input [ng/kJ]. The volatile compounds tended to be detected more often and in significantly higher concentrations than the semivolatile compounds. The compounds that occurred most frequently and in the highest concentrations, nine volatile and six semivolatile, are listed in Table II.

In a recent study,[12] a subset of the available data was defined which consisted of only those data where specific compounds were identified in stack

TABLE II. Most frequent thermal destruct process stack emissions

VOLATILE COMPOUNDS	SEMI-VOLATILE COMPOUNDS
Benzene	Naphthalene
Toluene	Phenol
Carbon tetrachloride	Bis(2-ethylhexy)phthalate
Chloroform	Diethylphthalate
Methylene chloride	Butylbenzylphthalate
Trichloroethylene	Dibutylphthalate
Tetrachloroethylene	
1,1,1-Trichloroethane	
Chlorobenzene	

emission but not in the waste burned (i.e., PICs). These data were used to compare emissions from incinerators, boilers, and kilns as shown in Table III. Three of the semivolatile compounds listed earlier were not included because there was minimal data for comparison. The data in Table III show that values from test run to test run varied considerably, thus these data do not allow prediction levels for all three combustion devices. Many of the volatile compounds showed higher levels for boilers, and incinerators tended to show higher levels for semivolatiles.

Data were also available from several baseline (no waste firing) tests on boilers and kilns. The fuel for most of the baseline tests was oil or natural gas, with some coal burned in a few kiln tests. These data were used to compare emissions from hazardous waste combustion with combustion of fuel without hazardous waste. Table IV presents this comparison for volatile compounds. Sufficient data were not available for a similar comparison for semi-volatile compounds. Considering the wide range in values from test to test, the data in Table IV suggest there is little inherent difference between waste and fuel combustion in emissions of the volatile compounds shown in the Table.

Sufficient data for five semivolatile compounds were available to compare their emissions when burning hazardous waste versus their emissions from municipal incinerators and coal-fired power plants. Similar data were not available for volatile compounds. Table V presents this comparison. The four phthalate compounds in the table all show very similar emission rates from all three sources. Naphthalene emissions were lower for power plants then the other two sources. Again, the data suggests that for some compounds there is little inherent difference between combustion sources.

An additional concern many have expressed regarding the issue of PICs is that EPA risk assessments have been limited to only metals and the Appendix VIII organic compounds. Comparison of total hydrocarbon emissions with the total quantity of organic compounds emitted has revealed that only a relatively small percentage of the total hydrocarbon emissions have been identified (Table VI). This has raised the question of what other potentially hazardous compounds (Appendix VIII or non-Appendix VIII) might remain in the unidentified emissions and what additional risk these might pose.

TABLE III. Emission rates of specific compounds from incinerators, boilers, and kilns, ng/kJ

	Incinerators		Boilers		Kilns	
	Mean	Range	Mean	Range	Mean	Range
Benzene	87	2-980	30	0-300	580	290-1,000
Toluene	1.6	1.5-4.1	280	0-1,200	----	No data ----
Carbon tetrachloride	0.8	0.3-1.5	1.8	0-7.2	----	No data ----
Chloroform	3.8	0.5-8.4	120	0-1,700	----	No data ----
Methylene chloride	2.2	0-9.6	180	0-5,800	----	No data ----
Trichloroethylene	5.2	2.3-9.1	1.2	0-13	1.3	0.7-2.8
Tetrachloroethylene	0.3	0-1.3	63	0-780	----	No data ----
1,1,1-Trichloroethane	0.3	0-1.3	7.5	0-66	2.4	(One value)
Chlorobenzene	1.2	0-6.0	63	0-1,000	152	33-270
Naphthalene	44	0.7-150	0.6	0.3-2.1	----	No data ----
Phenol	7.8	0-16	0.3	0-0.8	0.02	0-0.05
Diethylphthalate	3.7	2.8-4.8	0.4	0.04-1.6	----	No data ----

EPA has had some of the incinerator test analyses reviewed to identify additional compounds.[12] This review showed that the quantity of volatile non-Appendix VIII compounds detected by GC/MS varied from only a fraction of the total quantity of Appendix VIII compounds in one case to twice the quantity in another case. For semi-volatiles, the search showed that the total of non-Appendix VIII compounds was 3 to 30 times the quantity of Appendix VIII compounds. Some of the non-Appendix VIII compounds identified in the highest concentrations were:

Acetone
Acetophenone
Benzaldehyde
Benzenedicarboxaldehyde
Benzoic acid
Chlorocyclohexanol
Cyclohexane
Ethylbenzene
Ethylbenzoic acid
Ethylphenol
(Ethylphenyl)ethanone
Ethynylbenzene
Phenylacetylene
Phenylbutenone

Cyclohexanol	1,1'-(1,4-Phenylene)-bisethanone
Cyclohexene	Phenypropenol
Dioctyl adipate	Propenylmethylbenzene
Ethenylethylbenzene	Tetramethyloxirane
Ethylbenzaldehyde	Trimethylhexane

TABLE IV. Volatile compound emission rates from hazardous waste and fuel combustion, ng/kJ

	Waste		Fuel	
	Mean	Range	Mean	Range
Benzene	120	0-1,000	320	0-1,100
Toluene	210	0-1,200	190	0-1,500
Chloroform	90	0-1,700	14	0-800
Methylene chloride	130	0-5,800	160	0-3,400
Trichloroethylene	1.8	0-13	1.5	0-14
Tetrachloroethylene	49	0-780	7.7	0-52
1,1,1-Trichloroethane	5.6	0-66	1.7	0-14

TABLE V. Semi-volatile compound emission rates from hazardous waste combustion, municipal incinerators, and coal power plants, ng/kJ

	Hazardous waste		Municipal waste		Coal power plant	
	Mean	Range	Mean	Range	Mean	Range
Naphthalene	17	0.3-150	71	0.4-400	0.5	0.06-1.8
Bis(2-ethylhexyl)phthalate	4.6	0-21	4.6	0.4-12	7.6	0.2-24
Diethylphthalate	1.2	0.04-4.8	0.5	0.0.9	2.8	0.4-5.7
Butylbenzyphthalate	3.7	0.7-23	-- No data ----		0.5	0.3-1.0
Dibutylphthalate	0.3	0-1.1	3.9	1.5-7.6	3.0	0.09-8.7

TABLE VI. Total appendix VIII compounds measured as percent of total hydrocarbon

	Mean	Range
Incinerators	12	0.3-44
Boilers	0.4	0.01-1.1
Kilns	14	0.1-50

The EPA Science Advisory Board has reviewed the available emissions data for incinerators. While they have concluded that incineration is an effective destruction technology, they also concluded that a complete risk analysis was limited by an incomplete knowledge of the full range of compounds which are emitted from the stack during thermal destruction of hazardous waste.[13] To address this issue, EPA will conduct an emissions test at a full-scale hazardous waste incinerator in the Fall of 1986 in an effort to quantify total mass emissions (TME). The project will employ a broader array of sampling and analysis techniques than used in previous testing. The difference between steady-state operation and operation with typical transient conditions will also be studied. It is hoped that this test will characterize emissions sufficiently to allow a complete risk assessment and verify previous conclusions on risks.

Capacity

There has been considerable debate recently regarding the need for increased hazardous waste thermal destruction capacity in the United States. This issue is important for two reasons. First, thermal destruction is being identified by EPA as best demonstrated available technology for many of the wastes which will be restricted from land disposal under HSWA. The dates when restrictions on specific waste streams become effective will be, in part, a function of the availability of permitted thermal destruction capacity to handle the amount of waste expected to be diverted from land disposal.

Capacity is also an issue in the issuance of permits to incinerate hazardous wastes at sea in specially-designed incineration ships. Approval of disposal at sea is, in part, dependent upon successfully demonstrating a sufficient need to do so (i.e., insufficient land-based capacity).

EPA has conducted several studies of thermal destruction capacity over the past several years.[11,14,15] The most recent data on incinerator capacity is summarized in Table VII. There are 208 operating incinerator facilities in the United States. Of these, 34 have final operating permits and 174 have filed final applications which are being evaluated. Design capacities were obtained for 87 percent of the 208 units. The design, or nameplate, capacity of these reporting units is 6.28 billion Btu/hr. Extrapolating this statistic to include all 208 incinerators subject to the RCRA regulatory program, the national

capacity could be 7.2 billion Btu/hr, which is equivalent to approximately three (3) million metric tonnes of hazardous waste per year. Fume incinerators which are incinerating liquid hazardous waste appear to be approaching their capacity (94 percent), followed by rotary kiln incinerators (77 percent).

TABLE VII. Estimation of available hazardous waste incinerator capacity by incinerator design

INCINERATOR DESIGN	NUMBER OF UNITS	AVERAGE DESIGN CAPACITY (Million Btu/hr)	UTILIZATION (Percent)	AVAILABLE CAPACITY (Million Btu/hr)	PERCENT WITH AIR POLLUTION CONTROL EQUIPMENT
Rotary Kiln	42	58.7	77	570	90
Liquid Injection	95	36.1	55	1540	42
Fume	25	29.5	94	40	40
Hearth	32	22.5	62	270	38
Other	14	23.8	--	110	--
Total or Average Values	208	37.6*	67**	2530	50

*181 incinerators reporting
** 90 incinerators reporting

The study also revealed that since 1981, almost 100 incinerators had withdrawn from the RCRA system because they either ceased operation or were no longer handling hazardous wastes. Also, of the 57 companies identified as marketing hazardous waste incinerators in 1981, 23 have either gone out of business, left the hazardous waste incinerator business, or put considerably less emphasis on this activity. Only one new company is pursuing this market. Apparently, many of the companies that were anticipating large growth in the incineration market in 1981 have abandoned the business as a result of selling only a few or no units since then. The remaining 35 manufacturers, however, reported that 111 new incinerators had been sold since 1981.

It is believed that 12 cement kilns have received the hazardous waste storage permits necessary to burn hazardous waste as a fuel in their processes.[16] This corresponds to a capacity of between 87,000 tonnes of waste per year. These estimates are one to four percent of the estimated potential cement kiln capacity. The available capacity estimates for wastes that could be destroyed

in cement kilns range from two (2) to six (6) million tonnes per year, or from 0.8 to 2.3 percent of the hazardous waste generated annually in the United States.

There are also over 43,000 industrial boilers in the United States of sizes and designs which are potentially able to achieve acceptable waste destruction.[7] Of this population, 5,500 boilers are located in the chemicals, petroleum refining, and paper industries. These boilers are accessible to about 70 percent of total hazardous waste generated and over 95 percent of all potentially combustible hazardous waste, and are the most likely boiler candidates for waste firing. EPA estimates that approximately 1300 boilers are actually disposing of 3.5 million tonnes of hazardous waste annually.[7] If the remaining 4,200 boilers in the chemicals industry were to begin using hazardous waste as fuel at an equivalent rate, this quantity could increase to 14.8 million tonnes/year.

The conclusion one draws from these data is that, in the very near term, there appears to be sufficient thermal destruction capacity in the United States (Table VIII). In addition, if permits are granted for the two Vulcanus seabased incinerators, incineration capacity for liquid wastes could increase by 100,000 tonnes per year.

TABLE VIII. United States thermal destruction capacity for hazardous waste (million tonnes per year)

Facility Type	Current Utilization	Capacity	% Utilization
Incinerators (land-based)	1.7	2.7	63
Industrial Boilers	3.5	14.8	24
Cement Kilns	0.9	2-6	15-45
Incinerators (ocean)	0	0.1	0

EPA has estimated the amount of hazardous waste which might be redirected to commercial incineration as a result of restrictions upon disposal in landfills, lagoons, and injection wells.[15] Each of these three restriction scenarios are projected to result in an excess of commercial incineration demand over existing capacity of 215 to 306 percent for liquid wastes alone. Translated into facilities, this converts to as many as 26 incinerators (20,000 tonnes each). Solid hazardous waste and Superfund clean-up residues would further increase the shortfall.

While there are many boiler and kiln facilities which could dispose of waste, much of the waste which will become available for use in these thermal destruction

facilities in the future is likely to be increasingly less attractive to them. This waste will tend to be much less combustible and higher in solids, ash, and water content and, therefore, more suited to more conventional commercial incineration facilities. Thus, unless the rate of commercial incineration facility permitting and construction increases (particularly for solid hazardous wastes) the effective capacity may well be insufficient for new wastes which will enter the system from land disposal restriction and Superfund clean-up activities.

Permits And Public Acceptance

While thermal destruction offers many advantages over existing hazardous waste disposal practices and may help to meet the anticipated need for increased waste management capacity, public opposition to the permitting of new thermal destruction operations has been strong in recent years. The normal time required for permitting new incineration facilities is three years. This time as well as and the expense of obtaining a permit may be greatly increased if public opposition exists.

The amount of public opposition to proposed permits for land-based incinerator facilities varies by location and type of waste. On-site facilities that directly serve a single waste generator have greater public acceptance than off-site, commercial incinerators that serve multiple generators in a large market area. Off-site facilities are often not perceived as providing sufficient economic benefits to the local community to offset the risks associated with the importation of wastes from other areas. On-site facilities are more clearly perceived as being linked to businesses that are important to the local economy, and are generally not perceived as being importers of hazardous waste. Opposition has tended to focus primarily on new off-site facilities, including incinerator ships, and on new applications to burn PCBs, which critics view as particularly hazardous.

In an effort to assess the dilemma of perceived benefits versus public concerns, EPA conducted an assessment in 1985 to determine if there was a need for a change in the Agency's approach toward regulating thermal destruction.[17] The major concerns reported by citizens included concern for:

- Hazardous material spills in storage, treatment, and handling.
- Environmental and health impacts of land-based and ocean facilities.
- Poor site selection processes.
- Distrust of incinerator owners and operators.
- Inability of government agencies to enforce compliance.

The study concluded that public opposition to both land and ocean incineration may decline somewhat if EPA addresses more fully some citizen concerns

regarding national regulatory strategy, local community impacts, equity of facility siting, public decision-making processes, and especially enforcement plans and capacity. There is a need to better communicate how health and environmental concerns and priorities are reflected in the Agency's regulations and standards. Better communication of EPA's overall regulatory policy, strategy, and activities for decisions on proposed permits for individual incinerator facilities or vessels is needed. Better public communication is also important for improving EPA's credibility with the public, which is a necessary foundation for the effective accomplishment of the Agency's mission.

CONCLUSIONS

Thermal destruction of hazardous waste in incinerators and certain industrial processes represents the most effective technique currently available for organic wastes. While current assessments reveal that the emissions of metals and hazardous organics from these facilities present no significant health risks, a variety of scientific and public concerns remain over their safety. EPA is striving to improve our understanding of thermal destruction through a full range of ongoing research designed to answer the remaining concerns and bolster public confidence in thermal destruction. This research includes investigations into the development of real-time indicators of incinerator performance, performance tests on untested and high hazard wastes streams, and assessments of the impact of thermal destruction process upsets on emissions of metals and incomplete combustion by-products.

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